Space Weather Technical Forecast

Issued on Saturday, 27 November 2021 at 12:45 Local

This technical forecast provides a four day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales

Space Weather Forecast Headline: Chance of G1/Minor Magnetic storms day 1 (27th) and day 2 (28th) due to CME arrival.

Analysis of Space Weather Activity over past 24 hours

Solar Activity: Solar activity has been Very Low over the past 24 hours, with no significant X-ray flares. There are currently two sunspot containing active regions on the visible disc. AR2898 and AR2990 are both Dai/Beta classification, with the later developing in the last 24-36 hours. No Earth-directed CMEs have been observed in the last 24 hours. There are a number of filaments, however, most notably across the Sun's southwestern quadrant, and these will be monitored for any potential lift.

Solar Wind / Geomagnetic Activity: The solar wind speed, as measured by DSCOVR at L1, was at background at 300-350km/s, with the density of wind declining from a peak of 16 ppcc at first to average levels of between 5 and 10 ppcc. The interplanetary magnetic field strength (IMF), Bt, was weak, below 7 nT, with a north-south range between -4 nT and +6 nT UTC, predominately positive (northward), but with a couple of periods of negative (southward) field. The phi angle was variable with some rotations between negative (towards the Sun) and positive (away from the Sun) values. Geomagnetic Activity was Quiet throughout (Kp 0-1).

Energetic Particles / Solar Radiation: The high energy proton flux (greater than 10 MeV) remained at Background levels. The high energy electron flux (greater than 2 MeV) as observed by GOES-16 reached High levels between 26/1310 UTC and 26/1955 UTC, reaching a peak value of 2340 pfu at 26/1605 UTC. The associated 24-hour integrated fluence remained below the Active threshold (1e8 integrated pfu), with a rising trend, reaching 6.15e7 integrated pfu at 27/0000 UTC.

Four-Day Space Weather Forecast Summary

Solar Activity: Solar activity is expected to be Low or Very Low, with a chance of C-class flares from either of the two active regions currently on the disc. There is also an above background risk (5%) of isolated M-flares (R1 Blackouts)

Solar Wind / Geomagnetic Activity: CME arrival is anticipated 27/2300 UTC +/- 9 hours, due to a filament eruption on the 24th, although confidence is low regarding impacts due to the bulk of the material passing underneath Earth (south). A further filament eruption early on the 26th has now been reassessed as likely missing, but with low confidence, giving a small chance of some impact at Earth late day 3 or day 4 (29th or 30th). Background solar winds may also increase later day 1 (27th) or day 2 (28th) due to the arrival of a weak fast wind from either of coronal hole 22 or 24, before declining back towards background. Quiet geomagnetic activity at first, likely becoming Unsettled to Active with a chance of G1/Minor Storms later day 1 (27th) or day 2 (28th). Easing back to mostly Quiet to Unsettled with a chance of Active thereafter.

Energetic Particles / Solar Radiation: The high energy (greater than 10 MeV) proton flux is expected to remain at Background levels. The high energy electron flux (greater than 2 MeV) should now ease back due to lack of further significant enhancements in the period, perhaps showing a late uptick from any incident CME from day 2 onward, with the subsequent fluence

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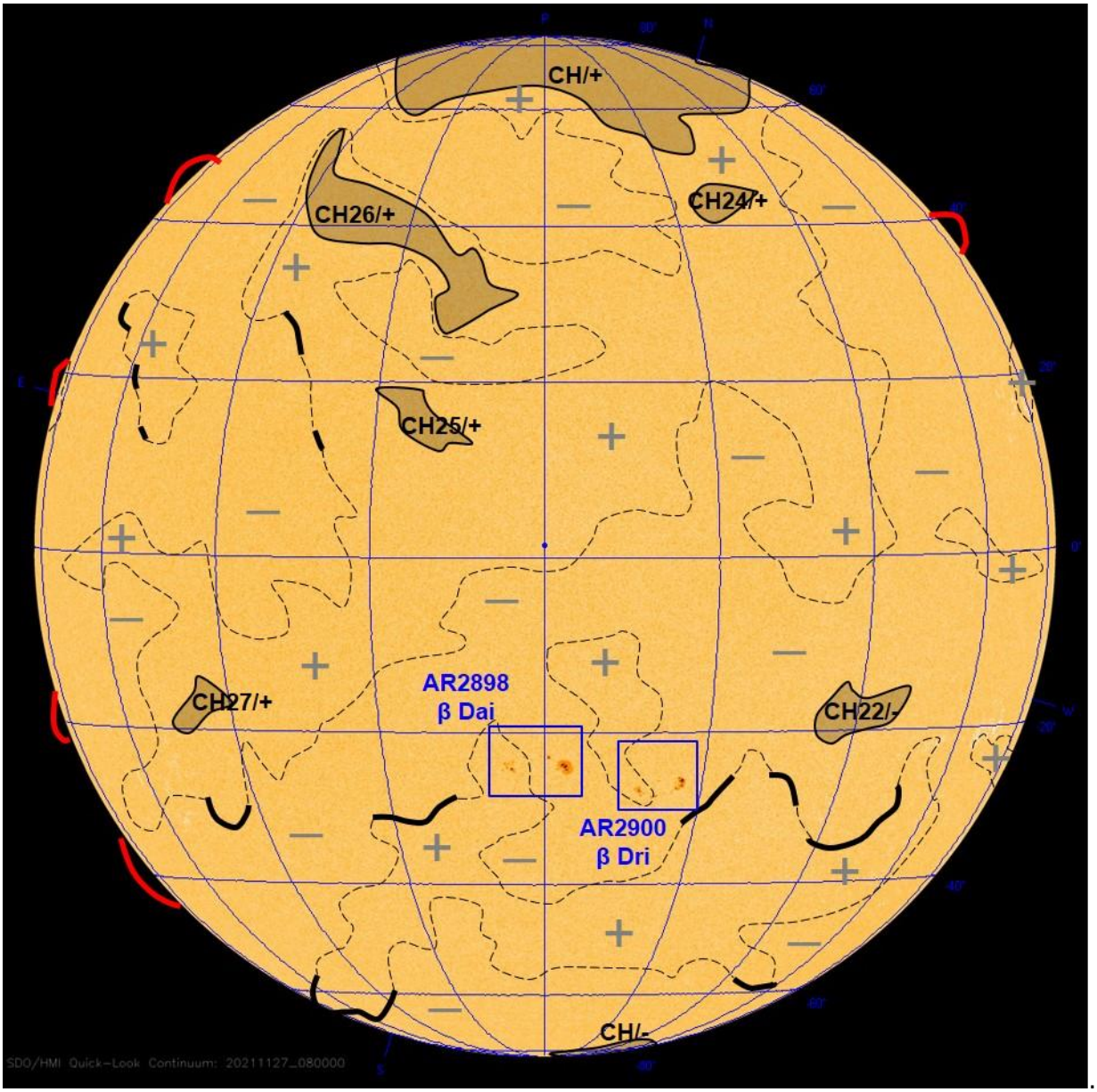
rising as a result, but currently expected to persist at below the Active (1e8 integrated pfu) threshold.

Figure 1. Solar Analysis Valid 27/0800 UTC.



Key: Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

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Geomagnetic Storms:

A CME arrival is expected later on day 1 (27th). This is due to a filament eruption which left the Sun on 24/1400 UTC. Whilst the bulk of material appears to be passing beneath the Earth, a partial halo visible on SOHO C2 and C3 imagery, and subsequent enlil analysis gives good confidence for some Earth impact, which has been assessed as likely occurring at 27/2300 UTC +/- 9 hours. A further filament eruption was observed from the northeast disc around 26/0010 UTC, however analysis of any subsequent CME has been difficult due to limited good imagery. Whilst currently not expected, a glancing impact is possible late day 3 (29th) or day 4 (30th).

Solar wind speeds are currently near background, although weak enhancements are possible from the fast winds of either of coronal hole 22 or 24 on day 1 or early day 2. Potentially alongside the anticipated first CME arrival. Otherwise, background winds are generally expected, with any fast wind or CME sourced enhancement soon declining.

Quiet geomagnetic activity at first, likely becoming Unsettled to Active with a chance of G1/Minor Storms later day 1 (27th), but most probably from any observed magnetic cloud that follows the CME arrival on day 2 (28th). Conditions easing back to mostly Quiet to Unsettled with a chance of Active thereafter, most likely with any further glancing CME later in the period.

Geo-Magnetic Storm Probability (Exceedance)	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Minor or Moderate	G1 to G2	No	30	40	5	10
Strong	G3	No	1	1	1	1
Severe	G4	No	1	1	1	1
Extreme	G5	No	1	1	1	1

Geomagnetic Activity - Earthbound Coronal Mass Ejections

CME-202111-029	24/11/2021 13:30	5E	22S	500	30	24/11/2021 20:58

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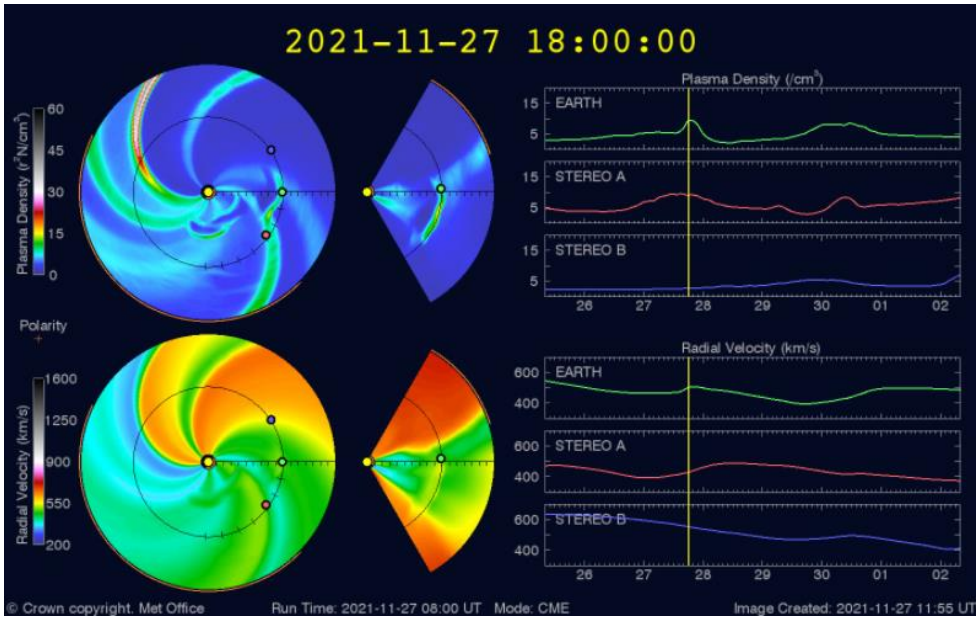
Figure 2: ENLIL with ensemble showing potential arrival later on the 27th, and also small chance of arrival later in the period.



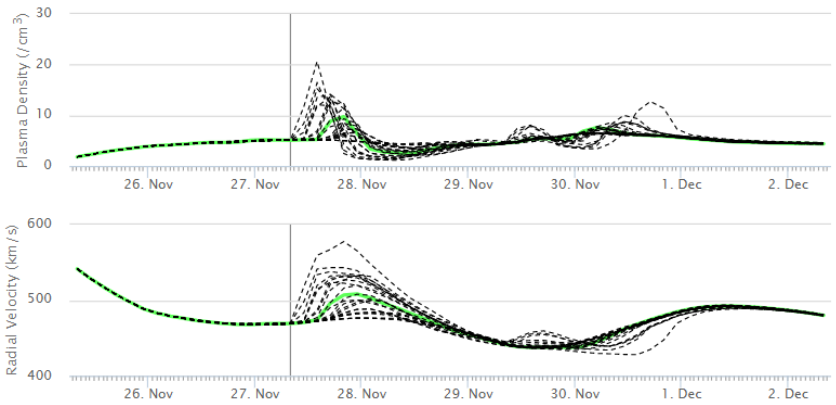
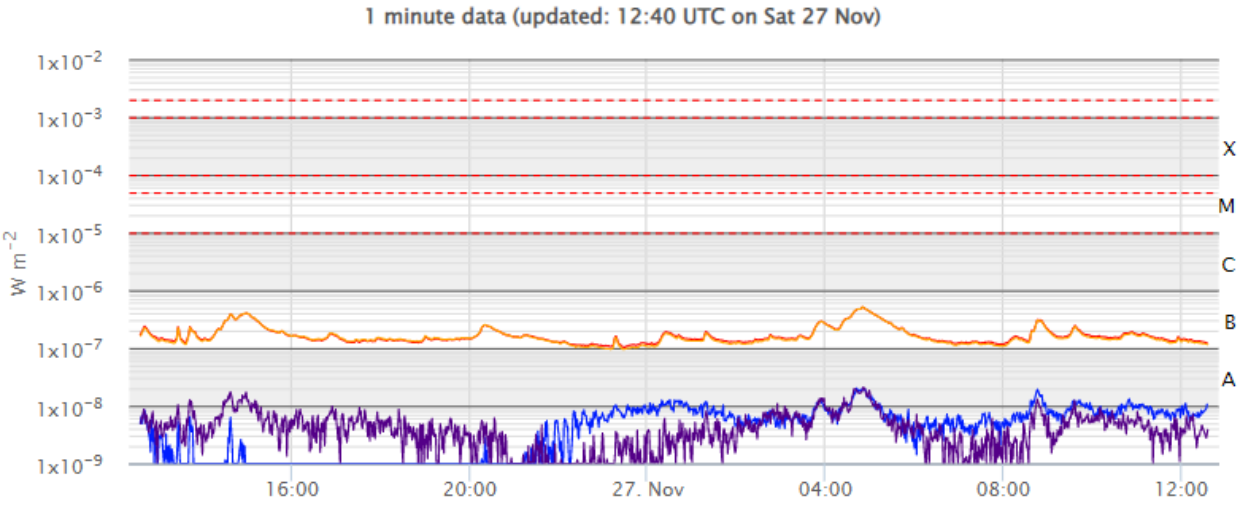


Figure 3: GOES-16 X-ray Flux



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Radio Blackouts - X-Ray Flares:

There are two sunspot containing active regions on the Earth-facing disc, AR2898 Dai/Beta and AR2900 Dai/Beta. These are both located in the southern central disc, with the former slightly larger and more central, and the latter to the west but more recently developing. There is also a plage region in the southwest disc, approaching the limb, that contains the remnants of Ex-AR2899, and a small plage region that has rotated onto the northeast disc contains some indication of a potential small spot region, and will be assessed over the coming 12-24 hours as it rotates into a clearer view.

Solar Activity has been Very Low with C-class X-ray flares or above observed by GOES-16/17. This has a chance to rise to Low, with the number of active regions on the disc, and there is an above background risk (5%) of this increasing to moderate from M-flares (R1-Blackouts).

X Ray Flares	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability			(%)	(%)	(%)	(%)
Active	R1-R2 M Class	No	5	5	5	5
Very Active	R3 to R5 X Class	No	1	1	1	1

Solar Radiation Storms - (High Energy Protons):

The high energy proton flux (greater than 10 MeV) as observed by GOES-16 is forecast to remain at background levels, with no solar radiation storms anticipated.

Radiation Storms	Level (cm^{-2} sr^{-1} s^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability (Exceedance)			(%)	(%)	(%)	(%)
Active	≥ S1	No	1	1	1	1
Very Active	≥ S3 *	No	1	1	1	1
* S3 ≥ 10 MeV ≥ 1000 pfu and / or ≥ 50 MeV ≥ 10 pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$)						

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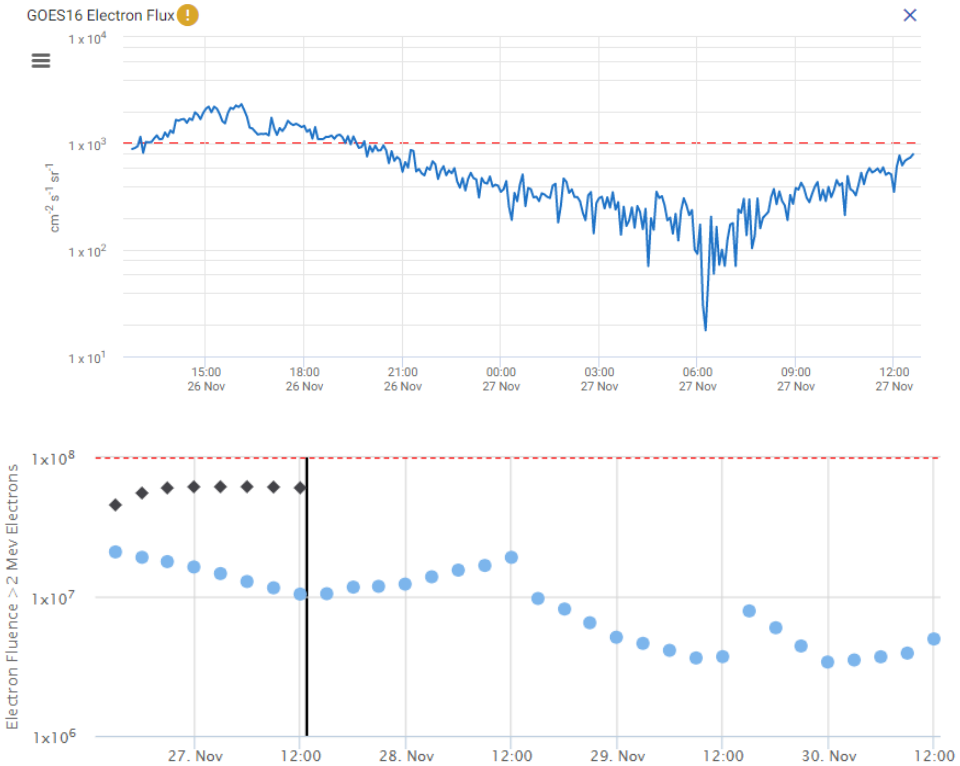
High Energy Electrons Event (≥ 2MeV):

The high energy electron flux as observed by GOES-16 has been exhibiting a diurnal variation between Moderate and High levels, with peak values rising day by day. However, current flux levels are running at a lower value than recent days, and with solar winds at background the diurnal maximum on day 1 (27th) is currently anticipated to be lower than that on the 26th. Flux levels will also decline further with any coronal hole fast wind enhancement or disturbance from the arrival of the anticipated CME. Once any initial geomagnetic disturbance has receded, there is the potential for Moderate to High electron flux levels to return from day 2 (28th) onward.

The associated integrated electron fluence is expected to remain below the Active threshold through the period, but after a small period of decline, rising in response to any coronal hole fast wind or CME arrival on day 1 or early day 2 (27th). REFM is currently giving a reasonable guidance, with fluence levels anticipated to stay below the Active level, but due to it being unaware of the potential CME arrival, is unlikely to be a good indicator beyond T+24.

GEO Electron Environment Probability (Exceedance)	Level (cm^{-2} sr^{-1} day^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ 2 MeV ≥ $1x10^8$**	No	1	5	10	10
Very Active	**≥ 2 MeV ≥ $1x10^9$**	No	1	1	1	1

Figure 4: GOES-16 Electron Flux and associated fluence with REFM



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